Characteristics of Hand, Foot, Trunk Side and Eye Dominance in University Athletes

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1. Introduction

There are some sports in which only one lateral of the body is mainly employed, while others require to use any lateral evenly to be performed by the characteristics of each sport. It may not be wise for a performer to engage in sports activities without concerning the dominant hand, foot, side and eye of his own or his opponent’s. To recognize own lateral dominance should be also convenient to make various movements and motions in the daily life activities.

The purpose of this study was to investigate the differences in the lateral dominances among various collegiate athletes by means of the questionnaire survey and the motor performance tests. Total of 443 athletes majoring physical education at the University of Tsukuba were surveyed of their cognitive lateral dominance by responding to the questionnaire. The motor performance tests consisted of 10 items all which were performed on each lateral so that the right and left differences could be compared.

2. Methods

2.1 Subjects: 320 male and 123 female (Total 443) physical education students of the University of Tsukuba who all participated in various sports were sampled for the questionnaire survey. The 320 male athletes described previously were served as the subjects of the motor performance tests, however, the female athletes were eliminated due to the small number of samples in some sports events. The events and numbers of the samples’ were followings: 22 male and 9 female of sprint run, 24 male and 1 female of middle and long distance run, 17 male and 4 female of jump events, 11 male and 2 female of throwing events, 30 male and 21 female of volleyball, 23 male and 27 female of basketball, 16 male and 20 female of team-handball, 28 male of baseball, 39 male of soccer, 20 male of rugby, 16 male and 11 female of swimming, 20 male and 22 female of gymnastics, 33 male and 8 female of Kendo, and 22 male of Judo.

2.2 Procedures

(1) Questionnaire survey: The questionnaire survey in this study was based on the original work of Akutsu’s ‘Lateral Dominance Questionnaire’ 25 questions in the hand dominance, 15 in the leg dominance, 8 in the trunk side dominance and 2 in the eye dominance were selected for the questionnaire as shown in page 130 of BIOMECHANISM 6.

(2) Motor performance tests: In order to measure and determine the lateral dominances, the following 10 items of motor performance tests took place; 1) grip strength, 2) arm strength, 3) tapping, 4) threading a needle in which the time of
threading three wires through three needle eyes was measured, 5) target accuracy which is a test to measure the time of humming the heads of pins in two lines on a table by using a Takei Target Accuracy Model, 6) leg strength, 7) stepping, 8) picking up a pencil which is a test to measure the time of picking up three round pencils lined on the floor by toes, 9) eye closed one-footed balance and 10) trunk twist.

2.3 Data collection and analyses: In the questionnaire all 50 questions were designed to respond either "R" for right, "L" for left, "A" for ambidexterity or "N" for no answer. The frequencies of each response to each question were counted and the percentages were calculated. The combinations of right (R), left (L), and ambidexterity (A) in the handedness, footedness, sidedness and eye dominance were also investigated and the percentage of frequencies in each appeared combination were calculated.

3. Results

3.1 Questionnaire survey: The critical point of handedness determination was set to whether more than 20 out of 25 questions in handedness were responded either "R" or "L". As presented in Table 1 the right-handedness was determined in 409 subjects (92.3 percent), the left-handedness was in 31 (7.0 percent) and the ambidexterity was in 3 (0.7 percent), respectively. The critical point of footedness determination was set to whether more than 8 out of 15 questions in footedness were responded either "R" or "L". The right-footedness was found in 273 subjects (61.6 percent), the left-footedness was found in 136 (30.7 percent), ambidexterity was found in 22 (5.0 percent) and 12 subjects (2.7 percent) were undiscerning. The question of the preferable side to twist the trunk was chosen to determine the sidedness because due to unsatisfied number of questions in the sidedness.

The combinations of right (R) and left (L) in handedness, footedness, sidedness and eye dominance obtained from the questionnaire were shown in Figure 1. R-R-L-R combination was the most supported by 82 subjects (19.7%), in order R-R-R-R of 75 subjects (18.0%), R-L-L-R of

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<th>Hand</th>
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<th>Eye</th>
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<tr>
<td>R</td>
<td>409</td>
<td>273</td>
<td>136</td>
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<td></td>
<td>(92.3)</td>
<td>(61.6)</td>
<td>(30.6)</td>
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<tr>
<td>L</td>
<td>31</td>
<td>136</td>
<td>217</td>
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<td></td>
<td>(7.0)</td>
<td>(30.7)</td>
<td>(49.0)</td>
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<tr>
<td>A</td>
<td>3</td>
<td>22</td>
<td>50</td>
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<td></td>
<td>(0.7)</td>
<td>(5.0)</td>
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<td>N</td>
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<td>12</td>
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<td>(0.0)</td>
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Table 1 Combinations of right(R), left(L), ambidexterity(A) and no answer(N) in handedness, footedness, trunk sidedness and eye dominance obtained from the questionnaire.

Fig. 1 Percent appearance of the combinations to right(R) and left(L) in handedness, footedness, trunk sidedness and eye dominance.
45 (10.8%), R-R-L-L of 38 (9.2%), R-L-R-R of 30 (7.2%), R-L-L-L of 27 (6.5%), R-R-R-L of 21 (5.1%) and R-R-A-R of 20 (4.4%) were found, respectively. The other combinations obtained were supported by small number of the subjects. Only one subject was the left dominance, L-L-L-L combination.

3.2 Comparison of Hand Dominance in Sports Groups:

1) Questionnaire survey: In the questionnaire average 23.4 out of 25 questions of the handedness were responded as “R” by the athletes of throwing events, which was the most of all 14 groups. The group of jump events had 22.5 of “R” responses and the group of judo had 22.1 of them, while the baseball group was the least of all with 20.9 of “R” responses to the handedness questions. As shown in the lower figure of Fig. 2 the groups of throwing events, swimming, team-handball and Kendo consisted of only right handed athletes in this study.

2) Grip Strength: The upper of Fig. 3 shows the mean scores of right grip strength and left grip strength in each sports groups. The throwing group performance was the largest in the grip strength followed by the Kendo, team-handball and basketball groups. The right-left difference in the grip strength was found in the team-handball group who showed +7.71 kg of the right hand dominance. The sequent groups were the throwing of +6.72 kg, the swimming of +5.76 kg and the volleyball of +5.25 kg, while the least was +0.3 kg of the rugby group.

3) Arm strength: The largest mean scores of right arm strength was presented by the throwing events group, and sequent groups were the Judo group and the rugby group. The left arm strength was largest in the Judo group and the throwing group and the rugby group were the sequent. The largest right-left differences in arm strength was found in the throwing group with +5.5 kg, and +4.5 kg of the Kendo, + 3.28 kg of the team-handball followed in sequence. The least right-left difference was found in the rugby group as well as in the grip strength.

4) Tapping: The number of times per
ten seconds of tapping performance in each sports group were shown in Fig. 4. The most score was presented by the volleyball group and the sequent groups were the jumping, the throwing and the baseball group. The largest right-left difference observed was +9.06 times of the team-handball group and to the next followed +8.0 times of the throwing, +7.64 times of the jumping and +7.08 times of the middle-long distance run groups. The least right-left difference of tapping scores was presented by the sprint group of +3.95 times, and the next was +4.71 times of the rugby group.

5) Threading a needle: The time of threading three wires through needle eyes was shown in Fig. 5. Except the team-handball group who performed slightly quicker on the left hands, all groups performed quicker on the right hands. The right-left difference was the largest in the throwing group who performed −6.62 seconds quicker on the right hand. To the next followed −4.13 sec. of the rugby and −3.17 sec. of the Kendo group. The least was measured as +0.25 sec. of the team-handball and −0.62 sec. of the gymnastic group.

6) Target accuracy: Fig. 6 shows the means of the target accuracy test scores, where all groups performed quicker on the right hands than the left. The quickest right hand target accuracy test was scored by the team-handball group and the gymnastics, the swimming and the Kendo groups followed to the next. The left hand performance by the team-handball group was also quickest and the jumping and the Kendo groups followed to the next. The right-left difference was the largest in the swimming group (−10.3 sec.), the gymnastics (−7.76 sec.) and the distance run group (−7.43 sec.).

Fig. 4 Upper figure shows the mean scores of right and left tapping performance per ten second. Lower figure shows the right and left difference in tapping times.

Fig. 5 Upper figure shows the means of right and left time of threading three wires through needle eye. Lower figure shows the right and left difference in threading time.

The least differences was −3.41 sec. of the jumping group.

3.3 Comparison of Leg Dominance in Sports Groups:

1) Questionnaire survey: The right leg dominant athletes who responded “Right” to more than 8 out of 15 questions in the footedness were compared in their of “R” responses by group and shown in the upper
The upper figure shows the means of right and left target accuracy test scores. Lower figure shows the right and left difference in target accuracy test.

Fig. 7 Upper figure shows the means of number of \( R \) responses to the footedness question. Lower figure shows the percent appearance of the right footedness in each group.

of Fig. 7. The means of number of \( R \) responses were 11.3 in the swimming group, 10.7 in the throwing group and 10.0 in the Kendo group, respectively. The soccer and the baseball group showed less right leg dominance with their means of 8.5. The lower figure in Fig. 8 shows the percent appearance of the right footedness in each group. In the sprint and the gymnastics group 90 percent of the subjects were the right footedness.

2) Leg strength: The upper of Fig. 8 shows the mean scores of the leg strength in each sports group. The largest mean was found in the throwing group, and the sequents were the Judo and the rugby. The least in the leg strength were found in the gymnastics and the distance run groups. The largest right-left differences of the leg strength was presented by +5.51kg of the sprint group, and +5.32kg of the jumping group and +4.27kg of the throwing group had followed. In the basketball and the distance run groups the right-left difference were hardly found.

3) Eye closed one footed balance: The upper of Fig. 9 showed the mean scores eye closed one footed balance. On the right foot the team-handball, the sprint run and the jumping groups performed longer than other groups, while the volleyball, the soccer, the sprint and the distance run groups performed longer than others the left foot. Six groups performed longer on the right foot than the left, while eight groups performed longer on the left foot.
The most right leg dominance was presented by the team-handball group whose right-left difference was 1.95 sec., while the volleyball group showed the most left leg dominance with -3.05 sec. of difference between right and left.

There were no statistically significant differences between the groups in the eye close one footed balance. The right-left differences were existed between 1 and 3 seconds which were also non-significant.

4) Stepping: All groups except the sprint run group performed more on their right feet than on their left feet in the stepping test (Fig. 10). The largest scores on the right foot were presented by the groups of the jump events, the throwing events and the sprint run in order. On the left foot the sprint, the jump and the soccer groups scored more than other groups. The right-left difference of stepping were +3.1 times in the gymnastics, +2.88 times in the jumping and +2.81 times in the throwing group, while the sprint group was -1.22 times. The right-left differences, however, were shown not as much as that of the tapping.

5) Picking up a pencil: The means of time of picking up three pencils with the right toes were shortest in the volleyball, the jump, the Kendo and the soccer groups in the order. The Kendo group scored 8.55 sec. with the left toes and the baseball, the distance running and the swimming groups followed next. The Judo group performed obviously longer than others with the left toes, therefore, their right-left difference was the largest of all with -8.01 sec. and the volleyball of -5.93 sec., the jumping group of -5.72 sec. followed next. On the other hand, the left foot dominance was found in the distance run of +5.93 sec., the baseball of +4.90 sec., the swimming of +2.54 sec., and the basketball of +2.45 sec., respectively.

3.4 Comparison of Trunk Side Dominance in Sports Groups:

1) Questionnaire survey: There were only 8 questions in the sidedness, therefore, it was unsuitable to determine one's sidedness by the numbers of "R" or "L" responses. The question of the preferable side to twist trunk was chosen to determine their trunk side dominance. As the results
the 38.6 percent of the subjects were determined as the right side dominance and 49.0 percent were as the left. The gymnastics, the swimming and the baseball groups had more number of "R" responses, while the distance run, the rugby and the Judo groups responded more "L" than other groups.

2) Trunk twist: The swimming, the Kendo, the soccer and the volleyball groups twisted more on their right side than the left, while in the other 10 groups the degrees twisted on their left side were larger than those on the right. The largest right-left differences were -3.9 deg. of the Judo, -3.7 deg. of the basketball and -2.8 deg. of the baseball group, though their standard deviations were too large to determine the significant differences among the groups.

4. Discussions

(1). Percent Appearance of Right or Left Lateral Dominance: There were 409 right hand dominants (92.3%) and 31 left hand dominants (7.0%) based on the questionnaire survey in this study. Mani and his co-workers had surveyed of 31 items in the handedness and footedness. According to Mani et al. the percent appearance of right handedness were 92.1% in male and 93.6% in female, while 6.7% and 5.0% of the left handedness were reported, respectively. The survey study in 256 female physical education students by Kimura and Asaeda reported 97.6% of the right handedness and 2.4% of the left handedness. Akutsu had surveyed in 155 college students and 274 athletes and reported that 91.6% of the right handed and 4.5% of the left handed college students, while that 90.6% of right and 6.2% of left handed in the athletes. The results of the questionnaire in this study seems to be coincided with the former studies, although slightly more left handedness has appeared in this study.

The determination of the lateral dominance legs seems not to be easy. To a simple question like "which is the dominant leg?" some may consider the leg used in kicking a ball or stone, and others may consider the one used in the take-off of the long jump or high jump. The former leg is the proficient or coordinated one to perform some skill, and the latter one means the stronger leg. In this study the majority number of the responses chosen to the question in the footedness was the determining parameter of each subject's footedness. The percent appearance of right leg dominance was 61.6% (273 subjects) and that of left leg dominance was 30.7% (136 subjects). By Mani and others 6) 60.8% of the right leg and 24.7% of the left leg dominance in the male students and 69.6% and 16.8% in the female were reported, respectively. Kimura and Asaeda in the female physical education students reported 49.6% appearance of the right footedness and 44.2% on the left. Akutsu found 71.1% appearance of the right leg dominance and 20.4% of the left in the college students and 55.8% of the right and 40.2% of left in the athletes. The percent appearance of the left leg dominance in this study was higher than that in the male students reported by Mani et al., but lower than in the athletes reported by Akutsu.

The manipulating leg was determined from the response to the questionnaire which asked the foot used on kicking a ball or pebble, while the take-off foot of broad jump was set for the determination of subject's supporting leg. The right-left combinations
Fig. 11 Relative Frequency Distribution of Right–Left Combination in Manipulating Leg and Supporting Leg.

R–RR : Right Handed with Right Manipulating Leg and Right Supporting Leg.
R–RL : Right Handed with Right Manipulating Leg and Left Supporting Leg.
R–LL : Right Handed with Left Manipulating Leg and Left Supporting Leg.
L–RR : Left Handed with Right Manipulating Leg and Right Supporting Leg.
L–RL : Left Handed with Right Manipulating Leg and Left Supporting Leg.
L–LL : Left Handed with Left Manipulating Leg and Left Supporting Leg.

of manipulating and supporting leg were shown in Fig. 11, where the relative frequency distribution of each combination was indicated by the length of each bar. In the swimming groups and the track and field events approximately the half of each group members were determined as right leg dominance for both manipulating and supporting leg, and the rest half had the right dominance for manipulating leg and the left for supporting leg. In the groups of ball games, martial arts and gymnastics approximately 25 percent of each group members were determined as right leg dominant for both manipulating and supporting leg, while more than 65 percent had the right dominance for manipulating leg and the left dominance for supporting leg.

In the sidedness the result of the questionnaire showed a slightly larger percent appearance of the left sidedness (49.0%) than of the right (38.6%). The preferable direction to rotate the upper body in the bilateral axes was the determination of the
subject’s sidedness, therefore, the left-sidedness imprecated the preference of the counter-clockwise torque of the bilateral axes of the body. Akutsu in the athletes provided their preferences of sideway to rotate the body in the cartwheel. He reported 33.3% preferred right and 57.8% preferred left, which seems to be coincided with the results of this study.

The 68.6% of subjects were the right eye dominance and 29.8% were the left eye dominance in this study. Parson provided the similar report of the 29.7% to 800 subjects of the left eye dominance. Ueda and Shimamura reported the larger percentage of the right eye dominance (84.4%) to 537 high school students, in which the left eye dominance percentage was 15.6%. In the study by Akutsu, the 69.0% of right eye and 19.0% of left eye dominance in the college students, however, he reported that in the athletes 45.0% were right eye and 18.1% were left eye dominance and 29.7% were undiscerning. This high percentage of undiscerning might be decreased by indicating a method to determine own eye dominance besides simply asking the eye dominance in the questionnaire.

From the combinations of right and left in the handedness, footedness, trunk sidedness and eye dominance, the R-R-L-R combination had the highest percentage of 19.7% because this combination consisted of the majority laterals in each four parameter. The absolute right dominance combination of R-R-R-R was found in 75 subjects, while only one subject appeared to be the absolute L-L-L-L left dominance combination. This seems to be coincided with Ogata’s statement that the left dominance seemed to be not a simple reverse lateral to the right dominance but rather one of the appearances of the ambidexterity.

(2) Right-Left Differences in Motor Performance Tests among Various Sports Groups:

1) Hand function: The muscle strength, agility and coordination in hands were measured with a grip strength, arm strength, tapping, threading a needle and target accuracy test in order to determine the functional handedness. The obvious right hand dominance in muscle strength was found to exist in the throwing group and the team-handball group. The Kendo group showed a large right-left difference of arm strength, although they had a slight difference of grip strength.

The right-left differences of hand agility were, similar to that of muscle strength, large in the team-handball and the throwing group and were small in the rugby and the sprinting group. The rugby group showed the slight right-left differences in both the cognitive test and performance test of handedness.

The hand coordination was measured with the threading a needle and target accuracy test. The throwing group showed the largest right-left differences in the threading a needle test, while the team-handball group showed that of the smallest. In the target accuracy, differently from the tendency shown in the strength or agility tests, the largest right-left differences were found to exist in the swimming, the gymnastics and the distance run groups whose movements in each event seem to require non-manipulation by right hand particularly.

2) Leg functions: the right-left differences of leg strength were about .4 to 5kg
in the athletes engaged in the track and field except the distance runners, while the other athletes showed about 1 to 3 kg differences between right and left which were not statistically significant due to the wide standard deviations in groups.

The right-left performance differences of the eye closed one footed balance and the stepping tests were not significantly different among the groups. However, that may be caused by not the characteristics of the sports but by the individual wide deviations due to the merely experienced motions in daily life activities.

3) Trunk side functions: the counter-clockwise torque of upper body was measured in larger scores than the clockwise torque by some groups such as the Judo, the basketball and the baseball whose sports movements involved many counter-clockwise torque.

Conclusions

(1) The percent appearances of the lateral dominance based on the questionnaire survey were as follows: the 92.3% of right, 7.0% of left and 0.7% of ambidexterity for the hand dominance, the 61.6% of right, 30.7% of left and 5.0% of ambidexterity for the leg dominance, the 38.6% of right, 49.0% of left and 11.3% of ambidexterity for the sidedness and the 68.6% of right, 29.8% of left and 1.1% of ambidexterity for the eye dominance.

(2). The various combinations of right and left in hand, leg, trunk side and eye were found to exist, and the percent appearance of the prime combinations were 19.7% of R-R-L-R, 18.0% of R-R-R-R, 10.8% of R-L-L-R and 9.2% of R-R-L-L, respectively.

(3). The throwing group showed the most right hand dominance in both cognitive and performance tests for the determinations of the handedness, while the rugby group showed less right-left differences than other groups in either test.

(4). As the result of the questionnaire survey the order of the strongest right leg dominance groups was the swimming, the throwing and the Kendo, while that of the left was the throwing, the soccer and the Judo group. In the swimming groups and the track and field events approximately the half of each group members were determined as the right leg dominance for both manipulating and supporting leg, and the rest half had the right dominance for manipulating leg and the left for supporting leg.

In the groups of ball games, martial arts and gymnastics approximately 25 percent of each group members were determined as the right leg dominant for both manipulating and supporting leg, while more than 65 percent had the right dominance for manipulating leg and the left dominance for supporting leg.

(5) The larger right-left differences of the trunk twist were found in the Judo, the basketball and the baseball who often use the trunk torque motions to the counter-clockwise direction in their particular sports movements.

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和文抄録

大学競技選手の利き手、利き足、利き体側、利き目の特徴

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本研究は、大学競技選手の意識的、機能的側優位性（利き側）を二種類の研究手段を用いて検討した。その第一は、アンケート調査による方法で、筑波大学体育学専門学群の競技選手443名の利き手、利き足、利き体側、利き目の研究をした。第二は、そのうちの男子320名について運動機能テストを実施したものである。

調査カードは手・足・体側・目の優位値を50項目についてよくものである。また運動機能テストは、1) 握力、2) 腕力、3) タッピング、4) 針糸通し、5) 狙準検査、6) 脳力、7) 闇眼棒片足立、8) ステツピング、9) 丸鉛筆拾い、10) 体捻転の10種目である。そして14種目の競技選手について10項目の運動機能テストの平均値を比較検討した。

（1）アンケート調査の結果は次のようである。

利き手意識に関する競技者自身の判定は、右手利き者92.3%、左手利き者7.0%であった。利き足については、右足利き者61.6%、左足利き者30.7%であった。利き体側については右体側利き者38.6%、左体側利き者49.0%であった。利き目にについては右目利き者68.6%、左目利き者29.8%であった。利き手、利き足、利き体側、利き目の重複をみると、R−R−L−Rが19.7%、R−R−R−Rが18.0%、R−L−L−Rが10.8%、R−R−L−Lが9.2%であった。調査項目のうち、「ボールや小石を振る時に使う足」によって器用足を、「走幅跳のふみきり足」によって支持足を判定し、左右足の組合せを作った結果、陸上競技、水泳の選手では器用足、支持足とともに右の者と、器用足は右で支持足は左というように機能の分化した者が半数ずつ居るのに対して、球技、武道、体操競技選手では器用足は右、支持足は左という者が65%以上を占めていた。

（2）運動機能テストの結果は次のようである。

握力については、ハンドボール、投擲、水泳選手が右手優位を示した。腕力については投擲、剣道、ハンドボール選手が右手優位を示した。タッピングについては、ハンドボール、投擲、跳躍選手が右手優位を示した。針糸通しについては、投擲、ラグビー、剣道選手が右手優位、狙準検査については、水泳、体操競技、中・長距離選手が右手優位を示した。脚力、閉眼棒片足立、ステツピング、丸鉛筆拾いについては、スポーツ種目間の平均値の差を分散分析によって検討したところ、グループ内の個人差に起因する変動が大きく有効水準に達しなかった。つまり、足の機能の差は、スポーツ種目の運動特性をみるためには十分であると結論される。

体捻転については、柔道、バスケットボール、野球選手が左側優位を示した。